Numerical simulation of precipitation phenomena during the monsoon season on the Tibetan Plateau

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Abstract

During the monsoon season, the precipitation variation on Tibetan Plateau is associated with synoptic-scale front passage or the meso-scale convection when the Tibetan High is dominated. Our purpose in this study is to simulate these precipitation phenomena and try to make the mechanisms clear.

In this work, our simulation results have been compared with the GAME-reanalysis data. For the two different situations (case 1 and 2), geo-potential height and wind, temperature and specific humidity at 250 and 500 hPa are consistent well with the GAME-reanalysis data. We also compared the simulated clouds with IRdata from METEOSAT-5.

Keyword: numerical simulation, precipitation on Tibetan Plateau, monsoon study

1. Introduction

During the monsoon season, the precipitation variation on the Tibetan Plateau is remarkable because it is strong affected by different dominate synoptic-scale meteorological systems in the middle latitude (Ueno et al., 2001). One is associated with the synoptic-scale front passage of the Plateau (hereafter, referenced as case1) and the other is associated the meso-scale convection on the Plateau over which large Tibetan High covered (hereafter, referenced as case2). But physical mechanism of these two precipitation is not clear. So our purpose in this study is to simulate the different precipitation phenomena (case1 and case2) with a non-hydrostatic numerical model, and try to make the mechanisms clear. In this work, we simulated the two different situations (case1 and case2) and compared the results with GAME-reanalysis data. And we also discussed characteristic of clouds from the detailed data.

2. Numerical Overview

The model we use is MRI/NPD-NHM (non-hydrostatic model developed by Institute of Meteorological Research/Japan Meteorological Agency). Initial data and boundary data were constructed from 0.5degree space resolution GAME-reanalysis data. Topography data is from GTOPO30. The model has 200×200 grid points in the horizontal directions and 38 layers in the vertical direction. The grid spacing in the horizontal directions is $\triangle x=\triangle y=30$km. One of calculation period we chose is during July 5 to July 8 in 1998 (case1), and the other is during July 29 to July 31 in 1998(case2).

3. Geography

Figure 1 shows the topography utilized

in the numerical simulation and GAME-reanalysis data, respectively. From the figure, we understand for the simulation study that: (1) Tian Shan mountains are located north-east of the Plateau and well representative; (2) Himalaya Mountains, especially for its south part, are also sharply representative.

4. Results and Discussion

4.1. Characteristic of the flows

Our simulation results have been compared with the GAME-reanalysis data.

First, we compared about geo-potential height and surface wind for two cases (Fig.2, 3). Fig.2 shows for case1 that the trough in the simulated result was clearer than that in GAME-reanalysis data. The obtained pressure gradient in simulation was stronger, so the wind speed was larger. Fig.3 indicates that the simulated Tibetan High was stronger and the wind speed was larger as same as in case1. In addition of the wind speed, the wind direction in reanalysis data was easterly while for the simulation it was westerly. Although there are some difference between the simulation and re-analysis data, the flow patters were very similar.

Next, we compared the temperature and specific humidity for two cases (Fig.4, 5). It is seen in case1 of the simulated result (Fig.4) that the temperature was higher about 2 K on the Plateau, and the specific humidity was also higher at the south part of Himalaya Mountains. For case2 (Fig. 5), the high temperature zone was bigger in the simulation because the Tibetan High was overestimated as compared with the re-analysis data. For the specific humidity it was higher around the Plate but lower on the Plateau. Generally, the temperature and specific humidity were realistically simulated.

4.2 Characteristic of the clouds

Here, we examined clouds. First, we checked convergence zone of the water vapor flux for two cases. Black zone in Fig.6 is convergence zone. Figure 7 shows the vertical integral cloud ice content for two cases. It is seen that formation of clouds is consistent with convergence zone.

Next, we compared this simulated results with IR data from METEOSAT-5. For case1, Fig.8 indicates that there were many clouds on or around Tibetan Plateau both in simulation and IR observation. It was shown that the simulated clouds are realistic. But, for case2 (seen in Fig.9) it was obvious that the simulated clouds were not realistic, as IR data showed much clouds on the Plateau but we couldn't get any cloud in simulation.

Reference

Ueno, K. Fujii, H. Yamada, H. Liu, L.: Weak and Frequent Monsoon Precipitation over the Tibetan Plateau. *J. Meteor. Soc. Japan,* 79-1B, 419-434, 2001

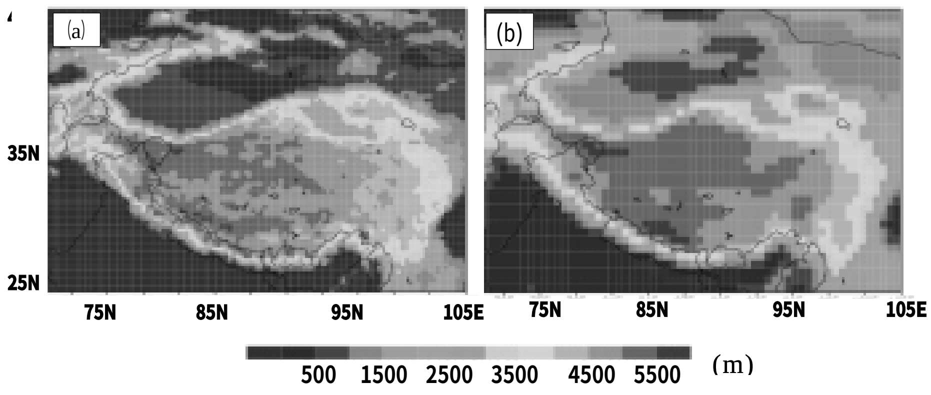

Fig.1 Topography utilized in simulation (a) and GAME-reanalysis (b).

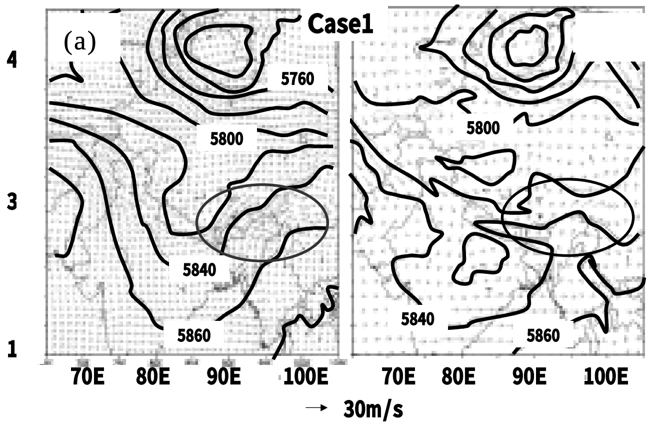

Fig.2 Geo-potential height and wind at 500 hPa at 00z on July 6 in 1998. (a) simulated result and (b) GAME-reanalysis data.

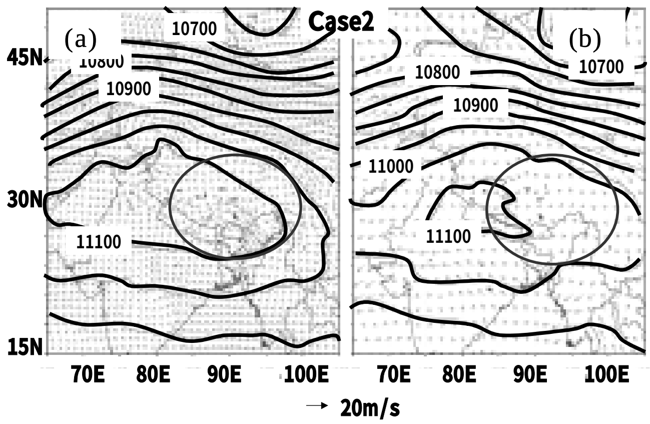

Fig.3 Geo-potential height at 250 hPa, wind at 500 hPa at 00z on July 31 in 1998. (a) simulated result and (b) GAME-reanalysis data.

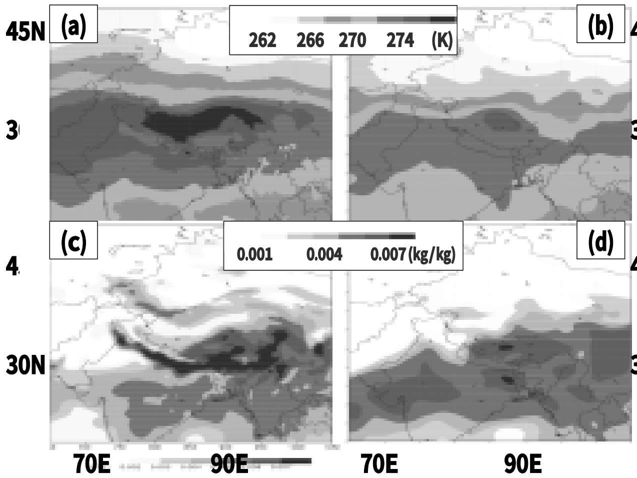

Fig.4 Temperature and specific humidity at 500 hPa at 00z on July 6 in 1998. Top figure is for temperature while bottom figure is specific humidity. (a),(c) simulated results; (b) ,(d) GAME-reanalysis data.

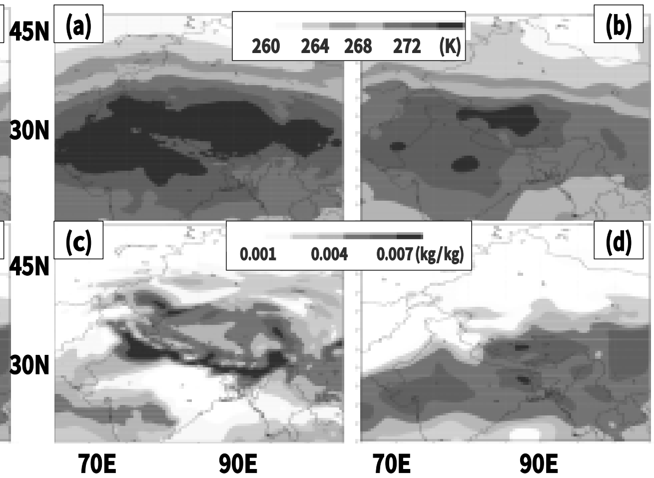

Fig.5 Temperature and specific humidity at 500 hPa at 00z on July 31 in 1998. Top figure is for temperature while bottom is for specific humidity. (a) and (c) are computation results, (b) and (d) are GAME-reanalysis data..

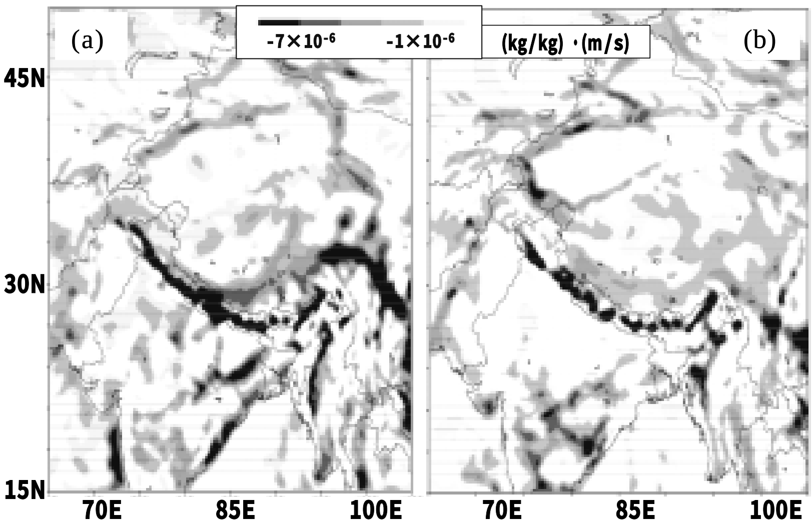

Fig.6 Convergence zone of the water vapor flux. The water vapor flux is estimated by integrating the date from surface to about 2000 m. (a) at 12z on July 8 in 1998 for case1, (b) at 12z on July 29 in 1998 for case2.

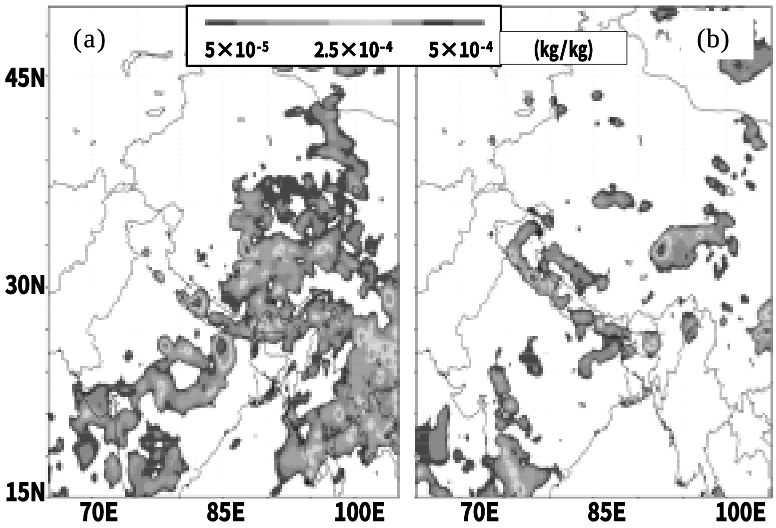

Fig.7 Cloud ice content integrated from about 1500 m to top (about 20 km). (a) at 12z on July 8 in 1998 for case1, (b) at 12z on July 29 in 1998 for case2.

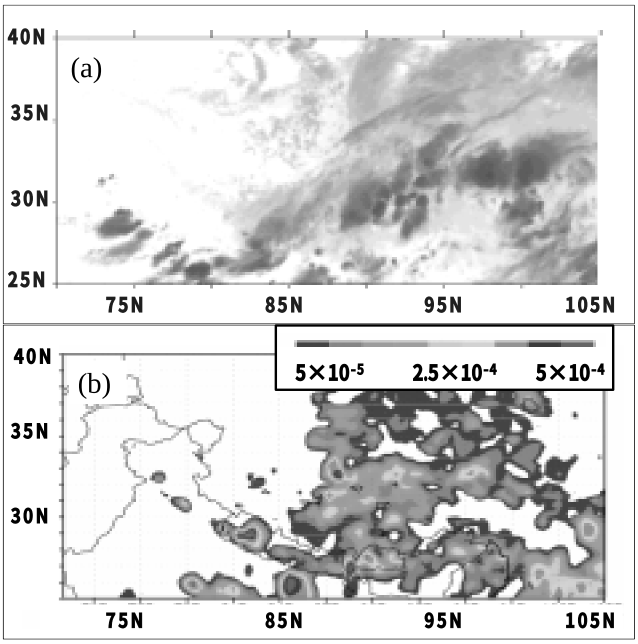

Fig.8 Characteristic of cloud at 12z on July 8 in 1998. (a) IR data from METEOSAT-5, and (b) calculated cloud same as fig.6 and 7.

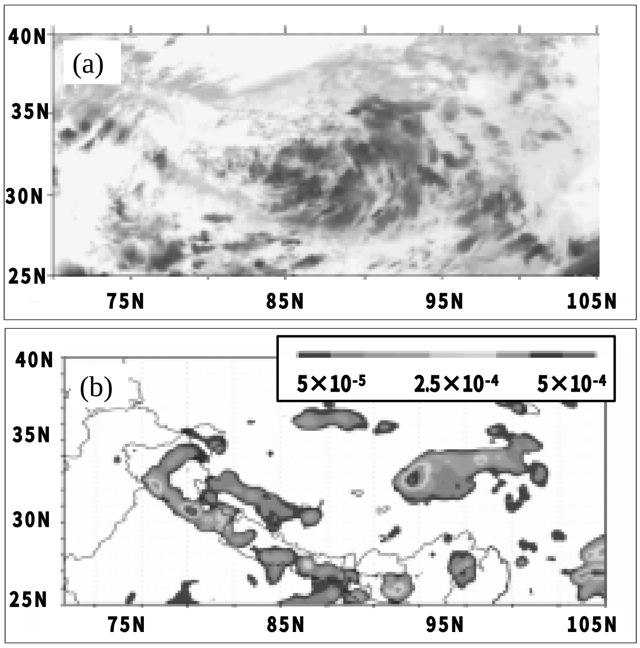

Fig.9 Same as fig.8 except for at 12z on July 8 in 1998.